

THE NOMENCLATURE OF THREE PACIFIC *BULLA* SPECIES

R. C. WILLAN

Zoology Department, University of Auckland, Private Bag, Auckland, New Zealand.

SUMMARY

The correct nomenclature is established for *Bulla quoyii* Gray in Dieffenbach, 1843, *Bulla angasi* Pilsbry, 1893 and *Bulla vernicosa* Gould, 1859. Full synonymies are given as well as descriptions and locality records.

INTRODUCTION

Now that comparative anatomical and ecological studies are being made on species of *Bulla* it has become critical to re-evaluate the abundance of earlier literature to stabilize the taxonomy of the common species of this important cephalaspidean genus. There has been considerable taxonomic confusion over the names of all the reasonably widespread species as evidenced by the 20 proposed specific names for the 3 valid species dealt with here.

Not only has there been a plethora of specific names but until recently there has been no unanimity regarding the most appropriate generic taxon itself. This confusion arose because Linnaeus (1758) first used *Bulla* as a subgenus of *Gryllus*, an orthopteran insect (p. 427), and only subsequently (p. 725) introduced it for a large series of molluscs. Later authors have therefore used all of the 5 following alternative names to designate this genus *sensu lato*: *Bullus* Montfort, 1810; *Bullaria* Rafinesque, 1815; *Bullea* Blainville, 1825; *Vesica* Swainson, 1840; *Quibulla* Iredale, 1929 (Dall, 1908; Iredale, 1929; Thiele, 1931; Pruvot-Fol, 1954; Abbott, 1954; 1974), although some have since been challenged or relocated. It is most fortunate that the name *Bulla* Linnaeus, 1758 has now been conserved by the International Commission on Zoological Nomenclature (Opinion 196, 1954) with the type-species by designation under the Plenary Powers: *Bulla ampulla* Linnaeus, 1758.

This publication examines the nomenclature of only 3 species of *Bulla* which are found in the Pacific Ocean. No synonymies have been attempted for other widespread Pacific species (e.g. *Bulla ampulla* Linnaeus, 1758; *Bulla punctulata* A. Adams in Sowerby, 1850) or more restricted species (e.g. *Bulla peasiana* Pilsbry, 1893 with type from Hawaii or *Bulla tenuissima* Sowerby in Reeve, 1868 with type from Swan River, West Australia) which occur in the Pacific area.

TAXONOMY

BULLA QUOYII GRAY IN DIEFFENBACH, 1843

Figures 15-24

- 1825 *Bulla australis* Gray, *Ann Philos* (New Series) 9: 408 [Australia]; 1827. Gray, in Capt. King's *Survey of Aust* 2 Appendix: 490, No. 92; 1835. Gray, in Yates' *Account of New Zealand* Appendix: 308; 1843. Gray, in Dieffenbach, *Trav N Z* 2: 243, No. 114 [New Zealand]; 1885. Brazier, *Proc Linn Soc N.S.W* 10(1): 89-91; 1903. Pritchard & Gabriel, *Proc Roy Soc Victoria* 15 (New Series) 2: 176-223 (non *Bulla australis* Ferrussac, 1822).
- 1833 *Bulla striata* Quoy and Gaimard, *Voy l'Astrolabe Zool* 2: 354, pl. 26, figs. 8, 9 [Bay of Islands, New Zealand and Jervis Bay, New Holland] (non *Bulla striata* Bruguière, 1792).
- 1833 *Bulla australis* Quoy and Gaimard, *Voy l'Astrolabe Zool* 2: 357, pl. 26, figs. 38, 39 [Port King George and Princess Royal Harbour]; 1836. Deshayes & Edwards, *Hist. nat. anim s. vert. ed.* 2, 7: 673; 1839. Deshayes & Edwards, *Hist. nat. anim s. vert. ed.* 3, 3: 348; 1852. Jay, *Cat shells*, ed. 4: 112, No. 3174; 1854. H. & A. Adams, *Gen. Rec. Moll.* 2: 16; 1859. Chenu, *Manuel de Conch.* 1: 389, fig. 2938; 1873. Von Martens, *List N.Z. Moll.* : 38; 1893. Pilsbry, *Man. Conch.* 15: 346, pl. 35, figs. 17, 18 (non *Bulla australis* Ferrussac, 1822).
- 1843 *Bulla quoyii* Gray, in Dieffenbach, *Trav N.Z.* 2: 243 [New Zealand]; 1874. E.A. Smith, *Voy. Erebus & Terror Zoology 1839-1843* 2: 5; pl. 1, fig. 11.
- 1850 *Bulla oblonga* A. Adams in Sowerby, *Thes. Conchyl.* 2: 577, No. 50, pl. 123, fig. 74 [Philippines and Anna Is.=error]; 1854. H. & A. Adams, *Gen. Rec. Moll.* 2: 16; 1867. Angas, *Proc Zool. Soc. Lond.*: 226, No. 257; 1868. Sowerby in Reeve, *Conch. Icon* 16, pl. 3, sp. 9, figs. a-c; 1873. Hutton, *Cat. Mar. Moll. N.Z.* : 244; 1877. Tenison-Woods, *Proc. Roy. Soc. Tasmania*: 47; 1880. Hutton, *Man. N.Z. Moll.*: 121.
- 1850 *Bulla castanea* A. Adams in Sowerby, *Thes. Conchyl.* 2: 584, No. 78a, pl. 124, fig. 106a [Shores of New Zealand].
- 1853 ?*Bulla* (*Bullea*) *substriata* Menke, *Zeit. f. Malakozool.* 10(9): 136 [New Holland].
- 1873 *Bulla quoyi* Gray, Hutton, *Cat. N.Z. Moll.*: 52, No. 245; 1880. Hutton, *Man. N.Z. Moll.*: 121; 1893. Pilsbry, *Man. Conch.* 15: 348, pl. 39, fig. 71.
- 1893 *Bulla australis* var. *oblonga* A. Adams, Pilsbry, *Man. Conch.* 15: 346-347; pl. 35, figs. 12-14.
- 1893 *Haminea castanea* A. Adams, Pilsbry, *Man. Conch.* 15: 374; Pl. 41, fig. 14.
- 1913 *Bullaria australis* Quoy & Gaimard, Suter, *Man. N.Z. Moll.* : 534; 1915. Suter, *Atlas*, pl. 49, fig. 6 (non *Bulla australis* Ferrussac, 1822).
- 1913 *Bullaria australis quoyi* Gray, Suter, *Man. N.Z. Moll.* : 535
- 1918 *Bullaria botanica* Hedley, *J. Proc. Roy. Soc. N.S.W. Suppl.* 51: M 104, No. 1104 (substitute name for *Bulla australis* Gray, 1825); 1958. May and MacPherson, *Ill. Index Tasmanian Shells*: 50, pl. 46, fig. 14; 1962. MacPherson and Gabriel, *Mar. Moll. Victoria*: 242, fig. 281.
- 1929 *Quibulla botanica* Hedley, Iredale, *Aust. Zool.* 5(4): 349, pl. 38, fig. 4; 1962. Allan, *Aust. Shells*: 199; 1962. Iredale & McMichael, *Mem. Aust. Mus.* 11: 88, No. 1852.
- 1937 *Vesica quoyi* Gray, Powell, *Shellfish N.Z.* (1st ed.): 84 (Fam. Bullidae)
- 1946 *Quibulla quoyi* Gray, Powell, *Shellfish N.Z.* (2nd ed.): 88 (Fam. Vesicidae); 1957. Powell, *Shells N.Z.* (3rd ed.): 111 (Fam. Bullidae); 1961. Powell, *Shells N.Z.* (4th ed.): 103; 1968. Morton & Miller, *N.Z. Sea Shore*: 543, fig. 202 (5); 1970. Rudman, *J. nat. Hist.* 5: 657-662, pls 8-12 (anatomy); 1970. Penniket, *N.Z. Seashells in Colour*: 68, pl. 31, fig. 2 (labelled fig. 4 in error).
- 1965 *Bulla* (*Quibulla*) *quoyi* Gray, Powell, *Rec. Auck. Inst. Mus.* 6(2): 167, pl. 22, fig. 10
- 1966 *Bulla botanica* Hedley, Burn, *Mem. Nat. Mus. Vict.* 27: 266; 1975. Coleman, *What Shell is that?* 14 (fig. 9).

REMARKS: The taxonomic confusion over the name of this species stems not only from Gray's (1825) and Quoy and Gaimard's (1833) independent introduction of the preoccupied taxon *Bulla australis*, but also that both Gray and Quoy & Gaimard proposed two names each: *Bulla australis* and *Bulla quoyii* of Gray (1825; 1843); *Bulla striata* and *Bulla australis* of Quoy & Gaimard (1833) all being introduced without adequate diagnosis or comparison. Brazier (1885) recognised that *B. australis* Gray and *B. australis* Quoy and Gaimard were conspecific and gave a full synonymy without referring to, or amalgamating, *B. quoyii* Gray or *B. striata* Quoy & Gaimard. Pritchard and Gabriel (1903) repeated the greater part of this synonymy but maintained "*Bulla quoyi* A. Adams" from New Zealand as a separate species. Other names that fall into synonymy are *Bulla oblonga* A. Adams in Sowerby, 1850, *Bulla castanea* A. Adams in Sowerby, 1850, *Bulla substriata* Menke, 1953 and *Bulla botanica* (Hedley, 1918), the latter having been introduced in a check list without description. It is this name which has become entrenched in Australian literature (Iredale, 1929; MacPherson & Gabriel, 1962; Allan, 1962; Iredale & McMichael, 1962; Burn, 1966; Coleman, 1975) whilst the combination "*Quibulla quoyi* (Gray, 1843)" has been consistently used in New Zealand works (Powell, 1946 et seq.; Morton & Miller, 1968; Rudman, 1970; Penniket, 1970).

Pilsbry (1893) tentatively placed *Bulla substriata* Menke in the synonymy of *Bulla australis* Gray, this synonymy may be correct, however since the type is lost it cannot be checked. Menke (1853)

himself admitted *substriata* was probably the same as *B. striata* Quoy & Gaimard but he had no access to their works to enable comparison.

The spelling of the name must revert to *quoyii*, in accordance with I.C.Z.N. article 32(a) since this is the correct original spelling of Gray in Dieffenbach, 1843.

TYPES: Following correspondence with Miss A. Blake of the Mollusca Section of the British Museum (Nat. Hist.) I have ascertained that the following type lots are held in that institution. Ten syntypes of *Bulla quoyii* are present (Reg. Nos 1842 11 18. 135-142), these having been received from Mr Stranger. The largest syntype (Reg. No. 1842 11 18 135) was figured by E. A. Smith (1874). Three syntypes of *Bulla oblonga* A. Adams in Sowerby are present (Reg. No. 197647). The probable holotype of *Bulla castanea* A. Adams in Sowerby is in the Lombe-Taylor Collection (Reg. No. 1881 5 20 22). This shell was purchased from Sowerby in 1881, it fits the figure and was originally labelled: "*castanea* - unique". However A. Adams in Sowerby does not state the source of his figured shell so it cannot be certain that this is the holotype.

DESCRIPTION: Adult size varies from 15 to 55 mm, shell thin, ovoid, whorls moderately convex; shell narrowed posteriorly and expanded anteriorly; apical cavity deep with sides slanting and reasonably perspective, revealing 4½ - 5 involute whorls; posterior edge of outer lip rises sharply above level of apical cavity, anterior portion of outer lip smoothly rounded. Shape and size are very variable (Willan, 1977). A smooth white callus is closely applied to the umbilical region and a thin opaque glaze extends from this callus the length of the parietal wall.

On the base of the shell are 9-24 incised spiral lines, with the SEM these lines resolve into an overlapping series of chisel-shaped punctae; these spirals are conspicuous on early whorls (*i.e.* on the ventral side of the body whorl) becoming weaker on the dorsal side of the last half whorl in adult shells. These spirals are virtually absent behind the outer lip in some of the largest shells the author has examined from New South Wales, Australia.

Occasionally one or two obsolete spiral lines are present near the apex; sculpture on spire whorls inside the apical cavity is of up to 5 incised spirals and occasional axial ribs on early whorls; some shells display an external pattern of gently undulating longitudinal flattened ridges (Fig. 20). Details of sculpture of the spiral lines and apical cavity have been presented elsewhere (Willan, *op. cit.*).

Shell colouration is of mottlings of purplish-grey, browns and white (Fig. 17); sometimes the whites and browns are arranged in irregular longitudinal streaks (Fig. 22); beach shells often take on a superficial milky-grey hue; in juvenile shells the mottlings can be orange-brown in colour; near-vertical walls of spire whorls are white in colour, although the apex of each whorl is brown. Mature shells may have a whitish glaze inside the outer lip and there may be a thickened white ridge parallel to the lip itself, the extreme edge of the outer lip is brown. Live shells are covered with a thin olive to orange-brown periostracum.

Details of anatomy have been given by Rudman (1970; 1971).

HABITAT: *Bulla quoyii* burrows in sand, which can be either fine or moderately coarse in texture, although the mollusc prefers a moderate silt fraction. *B. quoyii* is thus frequently found in conjunction with *Zostera* but individuals are occasionally found in intertidal pools amongst coralline turf. Subtidally the species is nocturnal, numerous live specimens have been seen on night SCUBA dives but never during the day.

LOCALITY RECORDS: NEW ZEALAND: Cape Maria van Diemen Beach; Pananehe Island, Spirits Bay; Pukenui Wharf area, Houhora Harbour; Paxton Point, Great Exhibition Bay; Kohotutea Point, near Cape Karikari; "The Lagoon", Cape Karikari; Main Beach, Mahinepua, near Whangaroa (all RCW); Waewaetoria Island (Coles Coll.); Motuarohia (Robertson) Island (RCW); Rawhiti Beach; Long Beach, Bay of Islands (both AIM); Bland Bay and Whangaruru Harbour; Tutukaka Harbour; Passage Island, southern side of Whangarei Harbour entrance (all RCW); Uikuhart's Bay, Whangarei Heads (AIM); Goat Island Bay, Ti Point, Matheson Bay, Leigh; Opahi Bay, Mahurangi Heads west; Waiwera Beach, Tiritiri Matangi Island; Army Bay and Shakespear Beach, Whangaraparoa Peninsula (all RCW); Takapuna Beach and Rangitoto Island; Cheltenham Beach; Howick Beach, Cockle Bay, Orakei Basin (all AIM); Beachlands Beach (RCW); Surfdale Beach, Waiheke Island (AIM), Waihou Bay, near Cape Runaway (RCW); Bark Bay, Nelson (RCW). QUEENSLAND: Trinity Bay (Hodge coll.). NEW SOUTH WALES: Shellharbour (AIM); Coogee (Hodge Coll.); Long Reef, near Manly (RCW); Bottle and Glass Rocks, Watsons Bay and Port Jackson (AIM; AWBP; RCW); Kurnell, Botany Bay (AWBP; RCW); Gunnamatta Bay, Port Hacking (RCW); Garie Beach; Bellambi Beach (both RCW). VICTORIA: Rosebud, Port Philip; Portland (both AIM). SOUTH AUSTRALIA: The Grange (RCW);

Outer Harbour, Adelaide (AIM); Stansbury (AWBP); Semaphore Beach (AWBP); Henley Beach (AWBP). TASMANIA: North Coast and Furneaux Group (May & MacPherson, 1958). S.W. AUSTRALIA: King George Sound and Princess Royal Harbour, Albany (Quoy & Gaimard, 1832).

DISCUSSION: Although *Bulla quoyii* exhibits greater variability than the other species examined here, it stands apart from all other Pacific bubble shells not only because of the basal spiral striae but also because of its light weight and relatively open umbilical cavity. Adult shells of *B quoyii* are larger in size in Australia. Suter (1913) listed "coasts of the North Island . . . also Australia and Tasmania" as the range of "*Bulla australis* Quoy and Gaimard". Iredale (1929) recognised the presence of spiral lines in "*Quibulla botanica*" and recalled that this feature had hitherto been considered a character solely of New Zealand specimens.

BULLA ANGASI PILSBRY, 1893

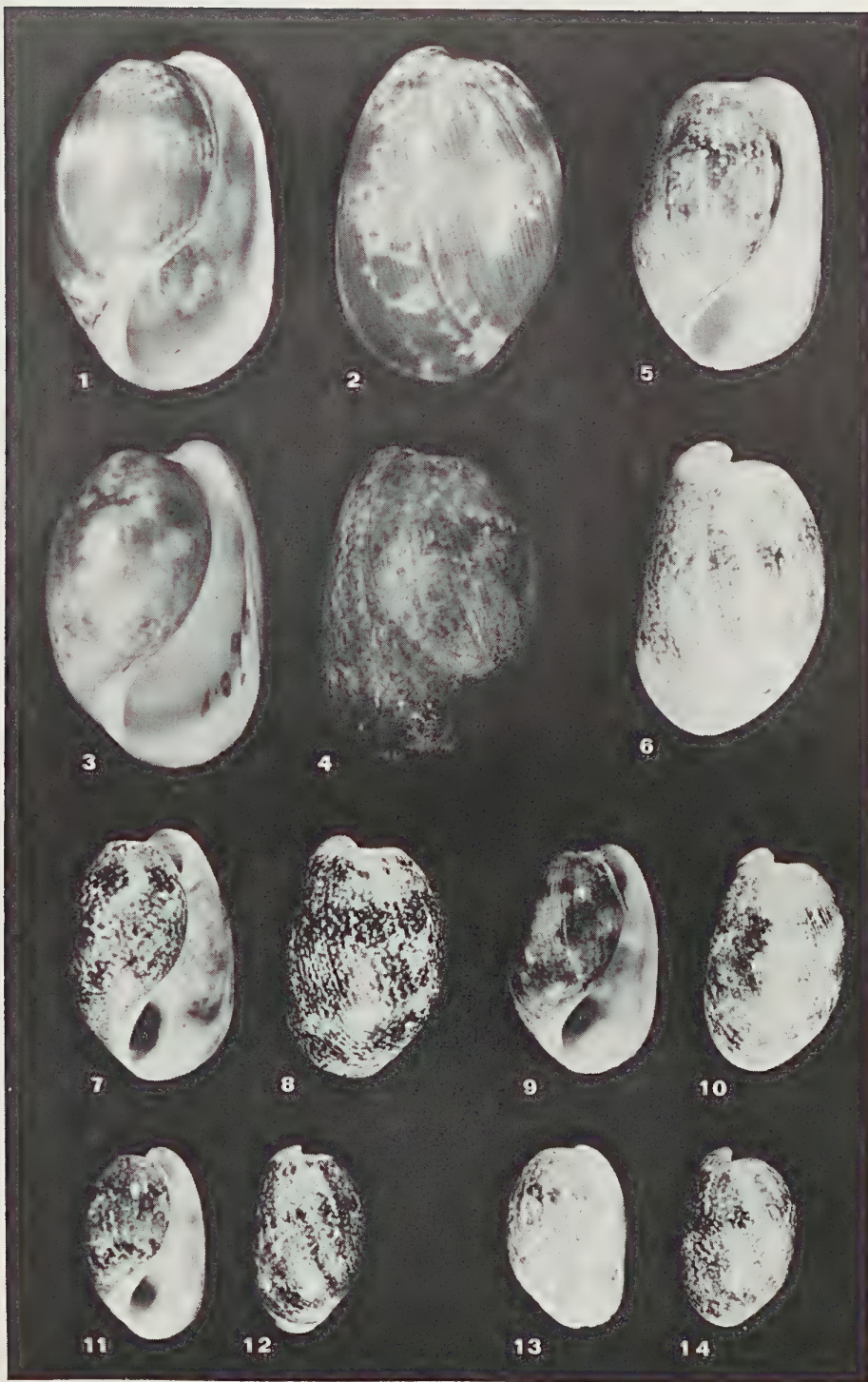
Figures 1-2, 25-37

- 1867 *Bulla solida* Gmelin, Angas, *Proc Zool Soc Lond* : 226 = No. 259 [Middle Harbour, Port Jackson]; 1868. Sowerby in Reeve, *Corch* Icon 16; pl. 4, figs. 10a, b [Hab.?:] (non *Bulla solida* Gmelin, 1791; nec Bruguiere, 1792)
- 1867 *Bulla magdelus* ("Lister", Angas, *Proc Zool Soc Lond* : 227, No. 260 [Middle Harbour, Port Jackson] (nom. nud.)
- 1867 *Bulla ovulum* Gould, Angas, *Proc Zool Soc Lond* : 227 [Middle Harbour and Long Bay] (published erroneously in synonymy of "*Bulla magdelus* Lister").
- 1893 *Bulla angasi* Pilsbry, *Man. Conch* 15: 347, pl. 36, figs. 32, 33 (substitute name for *Bulla solida* Sowerby in Reeve, 1868 and "*Bulla solida*" Angas, 1867 from Middle Harbour, Port Jackson).
- 1906 *Bulla adamsi* Menke, Suter, *Trans. N.Z. Inst* 39: 265 [Cape Maria van Diemen, N.Z.] (non *Bulla adamsi* Menke, 1850).
- 1913 *Bullaria adamsi* Menke, Suter, *Man. N.Z. Moll* : 534; 1915. Suter, *Atlas*, pl. 49, fig. 6 (non *Bulla adamsi* Menke, 1850).
- 1915 *Bullaria peasiana* Pilsbry, Oliver, *Trans. N.Z. Inst* 47: 542 [Kermadec Islands] (non *Bulla peasiana* Pilsbry, 1893).
- 1918 *Bullaria punctulata* A. Adams, Hedley, *J. Proc. Roy. Soc. N.S.W. Suppl.* 51: M 104, No. 1106 [New South Wales] (non *Bulla punctulata* Adams in Sowerby, 1850).
- 1929 *Quibulla angasi* Pilsbry, Iredale, *Aust Zool* 5(4): 350, pl. 38, fig. 8 [Sydney Harbour].
- 1937 *Quibulla scotti* Iredale, *Aust Zool* 8(4): 258, pl. 16, fig. 11 [Lord Howe Island].
- 1937 *Quibulla ovulum* Angas, Iredale, *Aust Zool* 8(4): 258 [Sydney Harbour]; 1962. Iredale & McMichael, *Mem. Aust. Mus.* 11: 88, No. 1854.
- 1965 *Bulla* (*Quibulla*) *subtropicalis* Powell, *Rec. Auck Inst. Mus.* 6(2): 167, pl. 22, figs. 8, 9 [type locality Norfolk Island; also in N.Z.].
- 1970 *Quibulla subtropicalis* Powell, Penniket, *N.Z. Seashells in Colour*: 68, pl. 31, fig. 3.
1971. *Bulla subtropicalis* Powell, Rudman, *J. nat. Hist.* 5: 662, 663 (anatomy).
- 1976 *Bulla vernicosa* Gould, Powell, *Rec. Auckland Inst. Mus.* 13: 159 [Cape Maria van Diemen to Whangarei Heads, N.Z.] (non *Bulla vernicosa* Gould, 1859).

REMARKS: Consideration of the most appropriate name rests on interpretation of the homonymous taxa "*Bulla solida* Gmelin" Angas, 1867 and *Bulla solida* Sowerby in Reeve, 1868. Pilsbry (1893) proposed the substitute name *A.* (that is *Bulla*) *angasi* for both *B solida* Sowerby (1868) from unknown locality and "*B solida* Gmelin" as of Angas (1867) from Middle Harbour, Port Jackson, Australia. Sowerby's specimen of *B. solida* is in the British Museum (Nat. Hist.), London, but Angas' specimen can no longer be traced. Since Pilsbry's substitute name was based on two different specimens, one from unknown locality and the other from Middle Harbour, it is

FIGURES 1-14.

- 1, 2. *Bulla angasi* Pilsbry, lectotype (= syntype of *Bulla solida* "Adams MS", Sowerby in Reeve, 1868. 35.3 x 23.7 mm. (British Museum Nat. Hist. 197646).
- 3, 4. *Bulla vernicosa* Gould, figured syntype of *Bulla ovula* "Gould", Sowerby in Reeve, 1868. 33.2 x 23 mm. (British Museum Nat. Hist. 197645).
- 5, 6. *B. vernicosa* Gould, Erakor Lagoon, Efate Island, New Hebrides. 46.3 x 29.8 mm.
- 7, 8. *B. vernicosa* Gould, Rarotonga Island, Cook Group. 38.2 x 26.5 mm. (Hodge Coll., Zoology Department, University of Auckland).
- 9, 10. *B. vernicosa* Gould, Tanna Island, New Hebrides. 35.5 x 23.7 mm.
- 11, 12. *B. vernicosa* Gould, Okinawa Island, Ryukyu Group. 29.6 x 19.8 mm. (Hodge Coll., Zoology Department, University of Auckland).
- 13, 14. *B. vernicosa* Gould, Luganville foreshore, Espiritu Santo Island, New Hebrides. 28.9 x 19.9 mm.



taxonomically advisable to select the only remaining syntype of Sowerby's *B. solida* as the lectotype of *B. angasi* Pilsbry. The lectotype of *B. solida* Sowerby (= *angasi* Pilsbry) (Figs. 1, 2) is in the British Museum (Nat. Hist.), Reg. No. 197646; length 35.3 mm, width 23.7 mm.

Angas (1867) used the invalid, mis-spelt and pre-Linnean name "*B. magdelus* Lister" for this species and in error included "*B. ovulum* Gould MS." in synonymy. The species "*B. ovula* Gould MS" as of Sowerby in Reeve, 1868, is actually the tropical Pacific species *B. vernicosa* Gould, 1859. Iredale's (1937) resurrection of the name "*B. ovulum* Angas" for the Sydney Harbour species is therefore inappropriate since this specific name designates an entirely different species which apparently does not occur at Sydney.

Iredale (1937) introduced *Quibulla scotti* for the Lord Howe Island population and also one dead shell from Elizabeth Reef and distinguished them from the Sydney Harbour forms, but the differences are no greater than those between New Zealand and Norfolk Island shells and can be encompassed within the limits of variation of *Bulla angasi*. The holotype of *Quibulla scotti* is in the Australian Museum (Reg. No. C60245) but there is some doubt as to its validity. Iredale states that the type is from Lord Howe Island and gives its dimensions as 40 x 27 mm but none of the material from Lord Howe Island in the Australian Museum approaches that size. On the other hand the shell from Elizabeth Reef is close in size (38 x 25.05 mm) and there is a note in the register dated 21 May 1937 in Iredale's own handwriting giving it as type. The figure given by Iredale closely matches this shell. So it would appear as though the specimen from Elizabeth Reef was intended as holotype of *Quibulla scotti* and Iredale got his localities confused (Ponder, *pers. comm.*). The holotype of *Bulla (Quibulla) subtropicalis* Powell is in the Auckland Institute and Museum (Reg. No. TM-1245), this name being a replacement for "*Bullaria peasiana* Oliver" from Norfolk Island, the Kermadecs and northern New Zealand.

DESCRIPTION: Shell moderately small (largest specimen examined 33 mm) solid and heavy, cylindrical; apical cavity a minute, straight-sided perforation. Posterior edge of outer lip rises above level of apical cavity; outer lip bends inward medially and is constricted posteriorly so that the outer lip runs parallel to the shell's longitudinal axis; the upper part of the aperture is therefore narrow; basally the outer lip is moderately expanded and rounded. A porcellan white callus covers the umbilicus and a thin glaze extends the length of the parietal wall; in fresh shells the underlying pattern remains visible through this glaze.

Shell smooth, there are no basal spiral lines, but incised spirals are present on the spire whorls in the apical cavity; the only external sculpture that can be present are longitudinal growth lines (Fig. 26).

Colouration is variable, generally consisting of a close mottling of chocolate or reddish-brown on a paler ground and clouded with small or large splotches of darker brown; occasional shells display a "punctulate" pattern (Figs. 29-31) reminiscent of *Bulla punctulata* A. Adams in Sowerby, but this pattern is never maintained with the consistency or accuracy of that species. Darker encircling bands can sometimes be distinguished; apical cavity white. Interior of aperture with a white glaze giving the shell its solidity; a thickened ridge is present parallel to the basal part of the outer lip but disappears medially where the outer lip bends inwards. Figs. 32, 33 illustrate a New Zealand shell with a colour pattern reminiscent of that of the lectotype.

The morphology of the radula and gizzard plates has been described by Rudman (1971) who found the anatomy of the soft parts to be very similar to *B. quoyii*.

HABITAT: *B. angasi* appears to live only subtidally and apparently only in habitats of relatively clean sand. Live specimens have been found on a mixed substrate of shell sand and coral gravel with small algae at Slaughter Bay, Norfolk Island (Rudman, 1971), these specimens were found at night crawling over the sediment surface in 4-5 m of water (R.V. Grace, *pers. comm.*). The present author has taken one specimen, which although dead still contained the animal, it was partially buried in coarse sand at the depth of 5 m at Matapouri Beach, Northland, New Zealand.

LOCALITY RECORDS: NEW CALEDONIA: Amadée Island, off Noumea; Thio (both RCW). NORFOLK ISLAND: (specimens in Coles Coll.; Hodge Coll.; AIM; AWBP; Hole Coll.; RCW coll.). NEW SOUTH WALES: Hungry Head, near Urunga; Long Reef, near Manly, Watsons Bay. Port Jackson (all RCW); Shellharbour, Kurnell, Botany Bay (AWBP); Elizabeth Reef (Iredale, 1937). LORD HOWE ISLAND: (Iredale, 1937). NEW ZEALAND: Cape Maria van Diemen Island (AIM); Cape Maria van Diemen Beach (AWBP; Hodge Coll.); Pananehe Island and Spirits Bay (Coles Coll.; Douglas Coll.; RCW); North Head and Paua Pt, Parengarenga Harbour (Douglas Coll.); Paxton Point,

Great Exhibition Bay (RCW); Rarawa Beach, southern end of Great Exhibition Bay (Coles coll.); Kohotutea Point, near Cape Karikari (RCW); Waewaetoria Island, Bay of Islands (Coles Coll.); Bland Bay, Whangaruru Peninsula; Matapouri Beach; Rocky Bay, Tutukaka Harbour; McGregors Bay, Whangarei Heads (all RCW); Great Barrier Island (AWBP) Mokohinau Islands (M. Mika Coll.); "Waterfall Reef" and "Echinoderm Reef", near Goat Island; Western side of Goat Island; Matheson Bay, Leigh (all RCW). KERMADEC ISLANDS: Raoul Island (AWBP); Denham Bay, Raoul Island (Douglas Coll.). WESTERN SAMOA: Beach 20 miles from Apia (Hole coll.).

DISCUSSION: Shells from New South Wales are indistinguishable from New Zealand material. Shells from the Norfolk Island population (type locality of *Bulla subtropicalis* Powell, 1965) are significantly larger ($P < 0.001$) having a mean length of 25.81 mm ($n = 37$) than those from New Zealand (mean length = 20.46 mm; $n = 34$) but specimens from these localities agree in other characters.

Cernohorsky (1972) placed *Bulla angasi* (as *B. subtropicalis* Powell) in the synonymy of *B. vermicosa* Gould; but *B. angasi* is more closely related to *B. punctulata* A. Adams in Sowerby and were it not for the sympatric existence of both *B. angasi* and *B. punctulata* in New Caledonia and Western Samoa one could consider the possibility of them being subspecies. A comparison of *B. angasi* and *B. vermicosa* is given in the discussion on the latter species.

BULLA VERNICOSA GOULD, 1859

Figures 3-14

- 1850 *Bulla australis* Quoy & Gaimard, A. Adams in Sowerby, *Thes. Conchyl.* 2(1): 576, pl. 127, figs. 64-66; 1868. Sowerby in Reeve, *Conch. Icon.* 16, pl. 4, figs. 12 a-c [Tahiti]; 1878. Brazier, *Proc. Linn. Soc. N.S.W.* 2(1): 83 [N.E. Australia, Islands of Torres Straits] (non *Bulla australis* Quoy & Gaimard, 1833).
- 1859 *Bulla vermicosa* Gould, *Proc. Boston Soc. nat. Hist.* 7: 138 [Loo Choo (Ryukyu) Islands]; 1862, Gould, *Otia Conch.*: 111; 1893. Pilsbry, *Man. Conch.* 15: 349; 1936. Hirase, *A. Coll. of Jap. Shells* (5th ed.): 90, pl. 118, fig. 12; 1950. Habe, *Ill. Cat. Jap. Shells*: 21, fig. 2; pl. 3, fig. 16; 1962. Kira, *Shells W. Pac. in Colour*: 114, pl. 40, fig. 13; 1972. Cernohorsky, *Mar. Shells Pac.* 2: 207, pl. 59, fig. 4.
- 1868 *Bulla ovula* "Gould", Sowerby in Reeve, *Conch. Icon.* 16, pl. 2, figs. 5a, b [Locality unknown].
- 1885 *Bulla adamsi* Brazier, *Proc. Linn. Soc. N.S.W.* 10(1): 92 (substitute name for *Bulla australis* A. Adams in Sowerby, 1850) [Tahiti, N.E. Australia, Torres Straits] (non *Bulla adamsi* Menke, 1850).
- 1893 *Bulla adamsi* Menke, Pilsbry, *Man. Conch.* 15: 345, pl. 35, figs. 15, 16, 19, 20; 1961. Rippingale & McMichael, *Qid and Gt Barrier Reef Shells*: 151, pl. 21, fig. 4; 1975. Coleman, *What Shell is That?*: 183, fig. 518 (non *Bulla adamsi* Menke, 1850).
- 1893 *Bulla vermicosa* var. *ovula* (Gould) Sowerby, Pilsbry, *Man. Conch.* 15: 349, pl. 36, figs. 34, 35.
- 1909 *Bullaria adamsi* Menke, Hedley, *Aust. Assoc. Adv. Sci.*: 370 [Queensland] (non *Bulla adamsi* Menke, 1850).
- 1938 *Bullaria (Bullaria) adamsi* Menke, W. Adam & LeLoup, *Rés. Sci. Voy. Indes. Orientales Néerlandaises*: 197 (non *Bulla adamsi* Menke, 1850).
- 1962 *Quibulla adamsi* Menke, Allan, *Aust. Shells*: 119 (footnote) (non *Bulla adamsi* Menke, 1850).
- 1965 *Bulla adamsii* Menke, Guang-Yu & Si, *Oceanologia Limnol. Sin.* 7(1): 2, pl. 1, fig. 1 (non *Bulla adamsi* Menke, 1850).
- 1966 *Bulla ovulum* Angas, Burn, *J. Malac. Soc. Aust.* 9: 96, figs. 1-4 [Southern Queensland] (non "*Bulla ovulum* Gould", Angas, 1867).

REMARKS: A future monograph on the genus may consider *Bulla vermicosa* Gould, 1859 to be insufficiently described since the original diagnosis is inadequate and there is no designated type. Some recent workers (Adam & LeLoup, 1938; Rippingale & McMichael, 1961; Allan, 1962; Guang-Yu & Si, 1965; Coleman, 1975) have followed Pilsbry (1893) in incorrectly using the name *Bulla adamsi* (or its unjustified emendation *adamsii*) Menke, 1850 for this tropical Pacific species. However the type locality of *B. adamsi* Menke is Mazatlan, Mexico and American authors place *B. adamsi* Menke in the synonymy of *B. punctulata* A. Adams in Sowerby, 1850 (Carpenter, 1872; Keen, 1971; Abbott, 1974).

Bulla adamsi Brazier, 1885 was a replacement name for *B. australis* A. Adams in Sowerby, 1850 an earlier preoccupied name for *B. vermicosa* Gould. Brazier was unaware his name was homonymous with *B. adamsi* Menke, 1850.

The name *Bulla ovulum* was never published by Gould (Johnson, 1964) and was therefore first validly published by Sowerby in Reeve, 1868, with the Loo Choo (= Ryukyu) Islands as type locality. Three syntypes (including the figured syntype) of *B. ovulum* Sowerby in Reeve are in the British

Museum (Nat. Hist.) Reg. No. 197645, and all are conspecific with *B. vernicosa* Gould. I have illustrated Sowerby's figured syntype in Figs. 3, 4.

The author has examined the *ex-pisces* shell from the Capricorn Group, one of two shells referred to "*B. ovulum* Angas" by Burn (1966) and finds it to be a rather elongate, and immature specimen of *Bulla vernicosa*. Burn's other shell from Rainbow Bay, Coolangatta is, judging by its description and illustration, also *B. vernicosa* Gould.

DESCRIPTION: Adult size up to 45 mm (a population of 27 adult shells from Luganville, Santo Island, New Hebrides had a mean length of 26.07 mm). Shell solid, globose, whorls convex; widest part of the shell near the middle, apical cavity moderately open and perspective, revealing 5-6 involute whorls. A white columellar callus is present but it is not totally reflected back onto the shell and leaves a narrow crescentric umbilical chink; a thin whitish or translucent glaze covers the parietal wall.

Shell smooth and polished, without any basal incised lines but up to 6 microscopic spirals are present on the involute whorls of the spire in the apical cavity; the only external sculpture is of numerous, close, longitudinal folds. Basic colouration is of a fine mottling of light brown and white over the whole shell, there can be 2-4 encircling bands of darker brown although the apical area is always lightly mottled, the apical cavity itself is white, fresh shells always have a highly polished, glazed external appearance. Interior of the aperture is thickened and white, adult shells have a low white ridge just inside the inner lip.

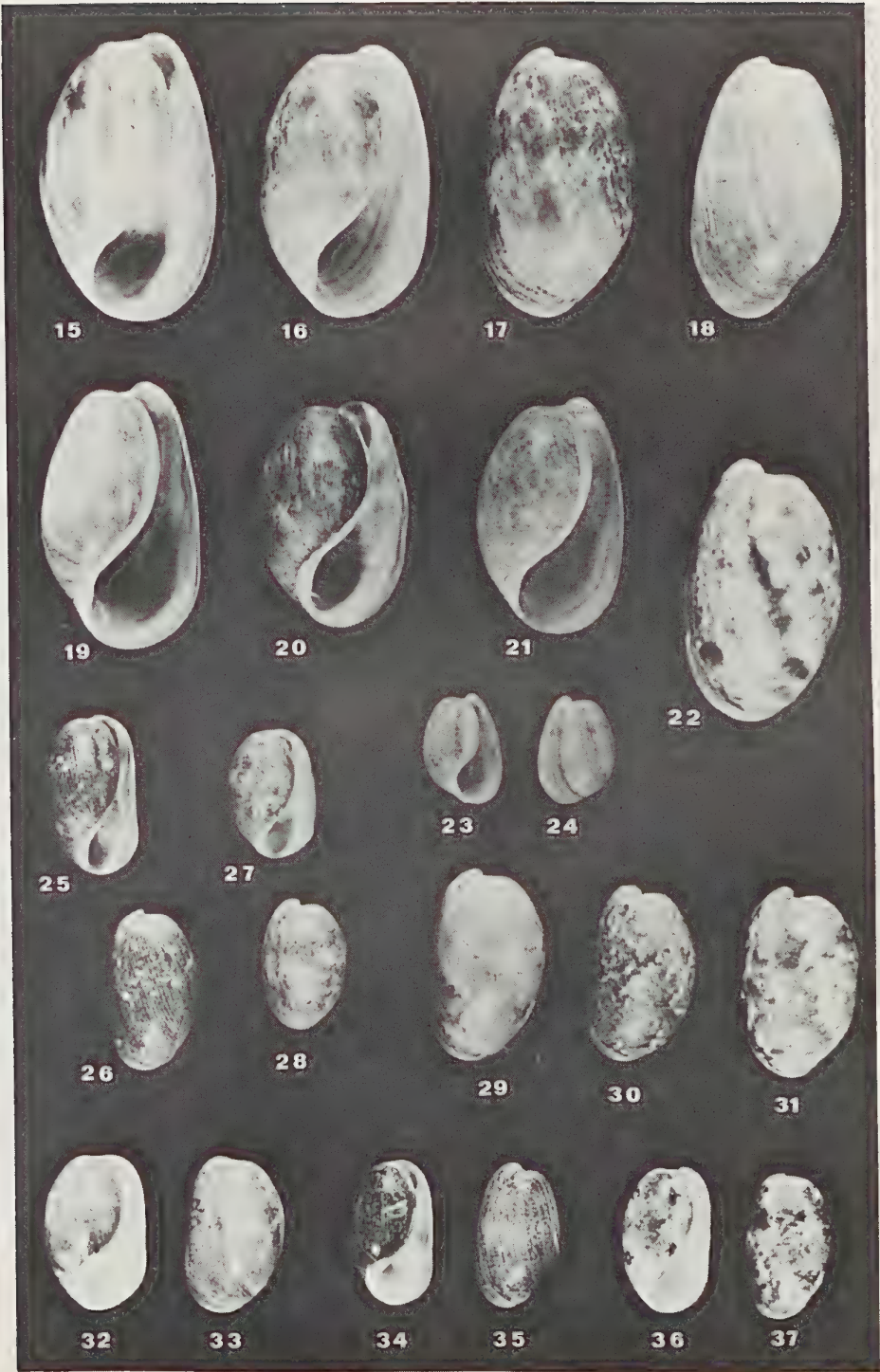
Details of anatomy have been given by Habe (1950) and Burn (1966). The author has examined the radulae of *B. vernicosa* from Lizard Island, North Queensland, and it is possible to reconcile the differences noted by Burn in respect to those of Habe in that the shape of the rachidian is dependent upon the orientation from which it is viewed; when observed flatly the rachidian has truncated sides; when tilted slightly forwards the sides of the rachidian appear to taper.

Live specimens observed at Lizard Island had light brown head shields and parapodia which were dappled with white, a darker band was present just in front of the eyes.

HABITAT: *Bulla vernicosa* is found throughout the tropical Pacific, frequently occurring sympatrically with *B. ampulla* Linnaeus and *B. punctulata* A. Adams in Sowerby. *B. vernicosa* inhabits lagoonal areas in the tropics, often in quite shallow water. Substrates in which it occurs range from clean coral rubble (e.g. Casuarina Bay, Lizard Island) to sand with a reasonable silt fraction (e.g. Erakor Lagoon, Port Vila, New Hebrides). Like *B. quoyii* and *B. angasi* it is nocturnal. I have found live specimens buried in fine sand beneath dead coral slabs during the daytime. Besides the nocturnal behaviour of the three *Bulla* species treated here, Abbott (1954) also noted that *B. occidentalis* A. Adams in Sowerby and *B. gouldiana* Pilsbry are to be found most abundantly at night and Robles (1975) both collected specimens of, and observed copulation in, *B. gouldiana* at night.

FIGURES 15-37.

15. *Bulla quoyii* Gray in Dieffenbach, The Grange, South Australia. 44.9 x 26.8 mm.
- 16, 17. *B. quoyii* Gray in Dieffenbach, Passage Island, southern side of Whangarei Harbour Entrance, New Zealand. 42.3 x 25.8 mm.
- 18, 19. *B. quoyii* Gray in Dieffenbach, elongate form, Mahurangi Heads West, North Auckland, New Zealand. 40.2 x 24.5 mm.
20. *B. quoyii* Gray in Dieffenbach, globose form, Bottle and Glass Rocks, Port Jackson, N.S.W. 30.2 x 24.1 mm.
21. *B. quoyii* Gray in Dieffenbach, Kohotutea Point, Cape Karikari, Northland, New Zealand. 35.6 x 22.0 mm.
22. *B. quoyii* Gray in Dieffenbach, Gunnamatta Bay, Port Hacking, N.S.W. 41.7 x 25.6 mm.
- 23, 24. *B. quoyii* Gray in Dieffenbach, adult of extremely globose form, Beach opposite Goat Island, Leigh, North Auckland, New Zealand. 16.1 x 11.8 mm.
- 25, 26. *B. angasi* Pilsbry, narrow form, Norfolk Island, 24.1 x 14.3 mm. (Hodge Coll., Zoology Department, University of Auckland).
- 27, 28. *B. angasi* Pilsbry, globose form, Rarawa Beach, Northland, New Zealand. 20.3 x 13.8 mm. (J. Coles Coll.).
- 29-31. *B. angasi* Pilsbry, colour variants, Norfolk Island. 29.1 x 18.7; 26.5 x 17.0; 29.3 x 19.0 mm respectively left to right.
- 32, 33. *B. angasi* Pilsbry, specimen with colouration matching lectotype, Rocky Bay, Tutukaka Harbour, Northland, New Zealand. 23.4 x 16.0 mm.
- 34, 35. *B. angasi* Pilsbry, Matapouri Beach, Northland, New Zealand. 22.3 x 13.4 mm.
- 36, 37. *B. angasi* Pilsbry, Amadée Island, New Caledonia. 22.7 x 14.5 mm.





Geographical distribution of *Bulla vernicosa* Gould (closed circles) and *B. angasi* Pilsbry (open circles). Map based only on localities from which specimens have been personally examined by the author. Map format courtesy of R. T. Abbott.

LOCALITY RECORDS: MAURITIUS: (AWBP). CHINA: Hainan Island (Guang-Yu & Si, 1965). JAPAN: (Habe, 1950; Kira, 1962). RYUKYU ISLANDS: Okinawa Island (AWBP; Hodge Coll.). CELEBES ISLANDS: Donggala (Adam & LeLoup, 1938). NEW GUINEA: Konori Island; Mioswoendi, Padaido Island (AIM); Manokwari (Adam & LeLoup, 1938). SOLOMON ISLANDS: Near Tulagi (AWBP). NEW HEBRIDES: Tanna Island, Erakor Lagoon and Mele Island, near Port Vila; Siviri Point, western end of Undine Bay (all Efate Island); Luganville foreshore and Tutuba Island (both Espiritu Santo Island) (all RCW). NEW CALEDONIA: Thio, Amadée Island off Noumea (both RCW). WESTERN AUSTRALIA: Broome (AIM); Roebourne (Hodge Coll.). QUEENSLAND: Nelly Bay, Magnetic Island; Casuarina Bay, western end of Lizard Island (AWBP); Rainbow Bay, Coolangatta; Capricorn Group (both Burn, 1966). FIJI: Pala'a Island (Hodge Coll.); Tevuki, Kandavu Island; North Coast, Viti Levu Island (both AIM); Manava Island (Cernohorsky, 1972). TONGA: (AWMP); Ma'apai Island (Hole Coll.). WESTERN SAMOA: (Hodge Coll.): Beach 20 miles from Apia (Hole Coll.); Pilot Point, Apia (AWMP); Moatoa Beach; Apia Harbour (both AIM). COOK ISLANDS: (AIM). RAROTONGA ISLAND: (Hodge Coll.).

DISCUSSION: *Bulla vernicosa* Gould is a distinctive tropical species because of its globose shape, relatively constant colour pattern and large apical cavity. It appears to be most closely related to *Bulla ampulla* Linnaeus. A careful comparison with the more temperate *B. angasi* shows several features to differ consistently in the two species. *B. vernicosa* is larger, its shell is globose with greatest width near the middle; the outer lip is evenly convex; the apical cavity is open and perspective; there is a narrow but open umbilical chink where the reflected umbilical callus does not quite rejoin the shell, this chink is most noticeable in juvenile shells; in the mouth the thickened ridge extends the whole length of the outer lip; colouration is relatively consistent and a "punctulate" pattern is never exhibited. *B. angasi* is smaller, the shell is constricted medially so that greatest width is near the base, the upper part of the aperture is narrow; the apical cavity is small with spire whorls hardly visible; frequently the umbilical callus is reflected completely back to the shell leaving no umbilical chink; the thickened ridge extends only to the medial constriction of the outer lip; colour patterns in any given population are variable and this species may exhibit a "punctulate" pattern.

ABBREVIATIONS USED IN TEXT

- AIM. Molluscan Collection, Auckland Institute and Museum.
 AWBP. A.W.B. Powell Collection, Auckland Institute and Museum.
 RCW. R.C. Willan Collection, Auckland.
 SEM. Scanning Electron Microscope.

ACKNOWLEDGEMENTS

I wish to express my thanks to Mr W. O. Cernohorsky for discussions on the nomenclature of the species dealt with here and also for access to the molluscan collections and library of the Auckland Institute and Museum. Thanks for information are also made to Mr. R. Burn and Mr. B. Marshall. Dr. W. F. Ponder kindly read the manuscript. Miss A. Blake of the Mollusc Section of the British Museum located Sowerby's specimens and these were photographed by Mr. P. A. Richens of that institution (Figs. 1-4). Mr. G. W. Batt has kindly taken the other photographs.

REFERENCES

- ABBOTT, R.T., 1954. *American Seashells*. First Edition. Van Nostrand. 542 pp.
 ——— 1974. *American Seashells*. Second Edition. Van Nostrand Reinhold. 663 pp.
- ADAM, W., and E. LÉLOUP, 1938. Résultats Scientifiques du Voyage aux Indes Orientales Néerlandaises etc., Prosobranchia et Opisthobranchia. *Mem. Mus. Roy. Hist. Nat. Belge* 2(19), 209 pp, 8 pls.
- ANGAS, G.F., 1867. A list of species of marine mollusca found in Port Jackson Harbour, New South Wales, and on the adjacent coasts, with notes on their habits etc. *Proc. Zool. Soc. Lond.* 1867: 185-233.
- ALLAN, J., 1962. *Australian Shells*. Georgian House, Melbourne, 487 pp.
- BRAZIER, J., 1885. Synonymy of and remarks upon the specific names and authorities of four species of Australian marine shells, originally described by Dr. John Edward Gray in 1825 and 1827. *Proc. Linn. Soc. N.S.W.* 19(1): 85-94.
- BURN, R., 1966. Some opisthobranchs from Southern Queensland. *J. Malac. Soc. Aust.* 9: 96-109, figs. 1-14.
- CARPENTER, P.P., 1872. Molluscs of western North America. *Smithson. Misc. Collns.* 252, 121 pp.
- CERNOHORSKY, W.O., 1972. *Marine Shells of the Pacific*. Volume 2. Pacific Publications, Sydney, 411 pp.
- COLEMAN, N., 1975. *What Shell is That?* Paul Hamlyn, Sydney, 308 pp.
- DALL, W.H., 1908. Report on the dredging operations etc., 14. The Mollusca and Brachiopoda. *Bull. Mus. Comp. Zool. Harv.* 43(6): 205-487, 22 pls.
- GOULD, A.A., 1859. Descriptions of new species of shells brought home by the North Pacific Exploring Expedition. *Proc. Boston. Soc. nat. Hist.* 7: 138-142.
- GRAY, J.E., 1825. *Ann. Philos. (New Series)* Vol. 9 (not seen).
- 1843. Shells. In E. DIEFFENBACH: *Travels in New Zealand; with contributions to the geography, geology, botany and natural history of that country* Volume 2. J. Murray, London. 396 pp, 1 pl.
- GUANG-YU, L and T. Si, 1965. Opisthobranchia from the Inter-Tidal Zone of Hainan Island, China. *Oceanologia Limnol. sin.* 7(1): 1-24, 3 pls.
- HABE, T., 1950. Hydatinidae, Bullidae and Akeridae in Japan. In T. Kuroda: *Ill. Cat. Japanese Shells*, No. 3: 17-24, 3 figs.
- HEDLEY, C., 1918. A check-list of the marine fauna of New South Wales. Part 1 - Mollusca. *J. Proc. R. Soc. N.S.W.* 51 (Suppl.): M.1 - M.120.
- IREDALE, T., 1929. Strange Molluscs in Sydney Harbour. *Aust. Zool.* 5(4): 337-352, pls. 37, 38.
- 1937. Mollusca, Middleton and Elizabeth Reefs, South Pacific Ocean. *Aust. Zool.* 8(4): 232-261, pls. 15-17.
- IREDALE, T., and D.F. McMICHAEL, 1962. A reference list of the Marine Mollusca of New South Wales. *Mem. Aust. Mus.* 11, 109 pp.
- JOHNSON, R.L., 1964. The Recent Mollusca of Augustus Addison Gould. *Bull. U.S. natn. Mus.* 239, 182 pp, 45 pls.
- KEEN, A.M., 1971. *Sea shells of Tropical West America* Second Edition. Stanford Univ. Press. 1064 pp.
- KIRA, T., 1962. *Shells of the Western Pacific in Colour*. Hoikusha Publ. Co., Osaka. 224 pp.
- LINNEAUS, C., 1758. *Systema Naturae per regna tria naturae* Tenth Edition. Stockholm. 824 pp.
- MACPHERSON, J.H. and C.J. GABRIEL, 1962. *Marine Molluscs of Victoria*. Melbourne Univ. Press. 475 pp.
- MAY, W.L. and J.H. MACPHERSON, 1958. *An Illustrated Index of Tasmanian Shells* Revised Edition. Govt. Printer, Tasmania. 72 pp.
- MENKE, K.T., 1853. Neue Arten der Gattung Bulla. *Zeit. f. Malakozool.* 10(9) : 136-144.
- MORTON, J.E. and M.C. MILLER, 1968. *The New Zealand Seashore*. Collins. 638 pp.
- PENNICKET, J.R., 1970. *New Zealand Seashells in Colour*. A.H. and A.W. Reed. 112 pp.
- PILSBRY, H.A., 1893. IN G.W. Tryon's *Manual of Conchology* 15. Philadelphia. 436 pp.
- POWELL, A.W.B., 1946. *The Shellfish of New Zealand* Second Edition. Whitcombe and Tombs Ltd. 106 pp.
- PRITCHARD, G.B. and J.H. GABRIEL, 1903. Catalogue of the Marine Shells of Victoria, Part 6. *Proc. R. Soc. Vict.* 15 (New Series) 2: 176-223.

- PRUVOT-FOL, A., 1954. Mollusques Opisthobranches. *Faune de France*, Part 58. Paul Le Chevalier, Paris. 460 pp.
- QUOY, J.R.C. and J.P. GAIMARD, 1832 - 1835. Zoologie: Mollusca. *Voyages de découvertes de l'Astrolabe*, sous le commandement de M.J. Dumont d'Urville. Vol. 2 and atlas. Paris.
- RIPPINGALE, O.H. and D.F. McMICHAEL, 1961. *Queensland and Great Barrier Reef Shells*. Jacaranda Press, Brisbane. 210 pp.
- ROBLES, L.J., 1975. The anatomy and functional morphology of the reproductive system of *Bulla gouldiana* (Gastropoda: Opisthobranchia). *Veliger* 17 (3): 278-291, 2 pls, 8 figs.
- RUDMAN, W.B., 1970. Studies on the Bullomorph Opisthobranchs. 16. On the reproductive system of the opisthobranch *Bulla quoyi* Gray, with notes on the mantle cavity and nervous system. Unpubl. Ph.D. thesis, University of Auckland.
- 1971. Structure and functioning of the gut in the Bullomorpha (Opisthobranchia), Part 1 - Herbivores. *J. nat. Hist.* 5: 647-675, 18 figs.
- SMITH, E.A., 1874. Mollusca. In J. Richardson and J.E. Gray: *The Zoology of the Voyage of H.M.S. Erebus and Terror*. Vol.2 Reptiles etc., 1844-1975. London.
- SOWERBY, G.B., 1868. Monograph of the Genus *Bulla*. IN L. REEVE, *Conchologia Iconica*. L. Reeve, London. Vol. 16, pls. 1-6.
- SUTER, H., 1913. *Manual of the New Zealand Mollusca*. Govt. Printer, Wellington. 1120 pp. 1915. Atlas of Plates. 72 pls.
- THIELE, J., 1931. *Handbuch der systematischen Weichtierkunde* 1(2), 778 pp. Jena.
- WILLAN, R.C., 1977. A macro- and microscopic examination of *Bulla quoyii* Gray in Dieffenbach (Mollusca: Opisthobranchia). *Auck. Mus. Conch. Sec. Bull.* 2 (New Series) : 11-17, 3 pls.